



# Microclimate Cooling and Power Requirement

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# Microclimate Conditioning Thermal Stress

Maintaining soldier performance during operations has always been a challenge.

High levels of physical activity, clothing and protective gear that prevents heat dissipation from the body, and the carrying of heavy combat equipment are hallmarks military operations.



# Microclimate Conditioning Mission

Our goal is to enhance warrior performance in hot and cold environments by reducing heat stress and enhancing protection against cold on the battlefield.

One way we're reducing heat stress on the battlefield is through the development of lightweight, low power microclimate cooling systems.



# Warrior Microclimate Cooling Requirements

## HOW MUCH COOLING?

### Depends on:

- Ambient Environment  
Temperature, Humidity, solar load, wind speed, etc
- Work Rate  
Between a low of 100 watts to a high of 500+ watts.
- Clothing Ensemble Characteristics  
Insulation, Vapor Permeability, etc



# Warrior Microclimate Cooling Requirements

The dismounted soldier metabolic heat production varies depending on activity levels:

- Very Light work rate 100-175 watts (e.g. guard duty=137w)
- Light work rate 125-325 watts (e.g. cleaning rifle=198w)
- Moderate work rate 325-500 watts (e.g. foxhole digging=475w)
- Heavy work rate 500+ watts (e.g. emplacement digging=540)

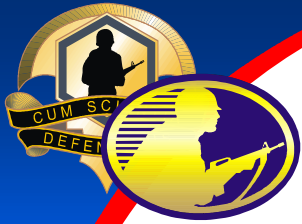


# Warrior Microclimate Cooling Requirements

The daily cooling requirement varies between a high of 1200 watt-hours and a low of 600 watt-hours.

The cooling rate of 300 watts has been shown to adequately reduce heat stress and enhance performance under a variety of environmental conditions, protective gear, and work rates.

Lower cooling rates of 200 and 100 watts have been shown to provide limited heat stress relief in temperate environment.



# Microclimate Cooling Technologies Investigated

**Foot Pump**  
**Ambient Air blower**  
**Thermoelectric**  
**Heat Pipe**  
**Air-Cycle**  
**Ejector Cooling**  
**Solid Absorption**  
**Liquid Absorption**  
**Stirling Cycle**  
**Vapor-Compression**

**Wetted Cover**  
**Vortex Tube**  
**Ice Phase Transition**  
**CO<sub>2</sub> Phase Transition**  
**Endothermic Reaction**  
**Heat Pipe**



# Microclimate Cooling Recommended Technologies

**Based on earlier studies these technologies were recommended and pursued:**

- ⇒ Vapor Compression cooling**
- ⇒ Solid Absorption cooling**
- ⇒ Ambient Air blower**
- ⇒ Stirling Cycle cooling**
- ⇒ Ice Phase cooling**





# Microclimate Cooling Efforts

## Recent microclimate cooling efforts:

Soldier Integrated Protective Ensemble Air Ventilation System - 1991  
Individual Microclimate Cooling System - 1994  
Personal Vapor Compression Cooling System - 1996  
Personal Ice Cooling System - 1996  
Advanced Lightweight Microclimate Cooling System - 1998  
Complex Compound Absorption Microclimate Cooling System - 2000

## Current microclimate cooling efforts:

Air Warrior Microclimate Cooling System - current Army program  
Advanced Concept Uniform cooling concept - current Army program  
Integrated Mesoscopic Cooling Circuits-current DARPA program  
Mesoscopic Adsorption Cooling System -current DARPA program  
Carbon Absorption Cooling - current DARPA program



# Microclimate Cooling Energy and Power

<b>Cooling System</b>	<b>Cooling rate/ Electrical power (watts)</b>	<b>Continuous/ Intermittent Duration (hours)</b>	<b>Minimum Daily Cooling Energy/ Electrical Energy (watt-hours)</b>
<b>300W MCC</b>	<b>300/150</b>	<b>2/12</b>	<b>600/300</b>
<b>200W MCC</b>	<b>200/100</b>	<b>3/12</b>	<b>600/300</b>
<b>100W MCC</b>	<b>100/50</b>	<b>6/12</b>	<b>600/300</b>
<b>Future 100W MCC</b>	<b>100/30</b>	<b>6/12</b>	<b>600/300</b>



# Ambient Blowers Energy and Power

Cooling System	Electrical Power (watts)	Continuous/ Intermittent Duration (hours)	Electrical Energy watt-hours
15 CFM AB	25	6/12	150
13 CFM AB	15	6/12	90
8 CFM AB	7	10/12	70



# Prototype Air Blowers

These efficient brushless DC air blowers are potential candidates for the Objective Force Warrior. They provide high flow rates at low weight and power. These blowers were demonstrated on the Predator concept.

## Blower Options:

- 24-volt / 15 CFM air flow @ 3 inch WG  
Power: 15 watts  
Weight: 2 Lbs.
- 12-volt / 13 CFM @ 3 inch WG  
Power: 15 watts  
Weight: 2 Lbs.
- 6-volt / 8 CFM @ 3 inch WG  
Power: 7 watts  
Weight: 2 Lbs.

